



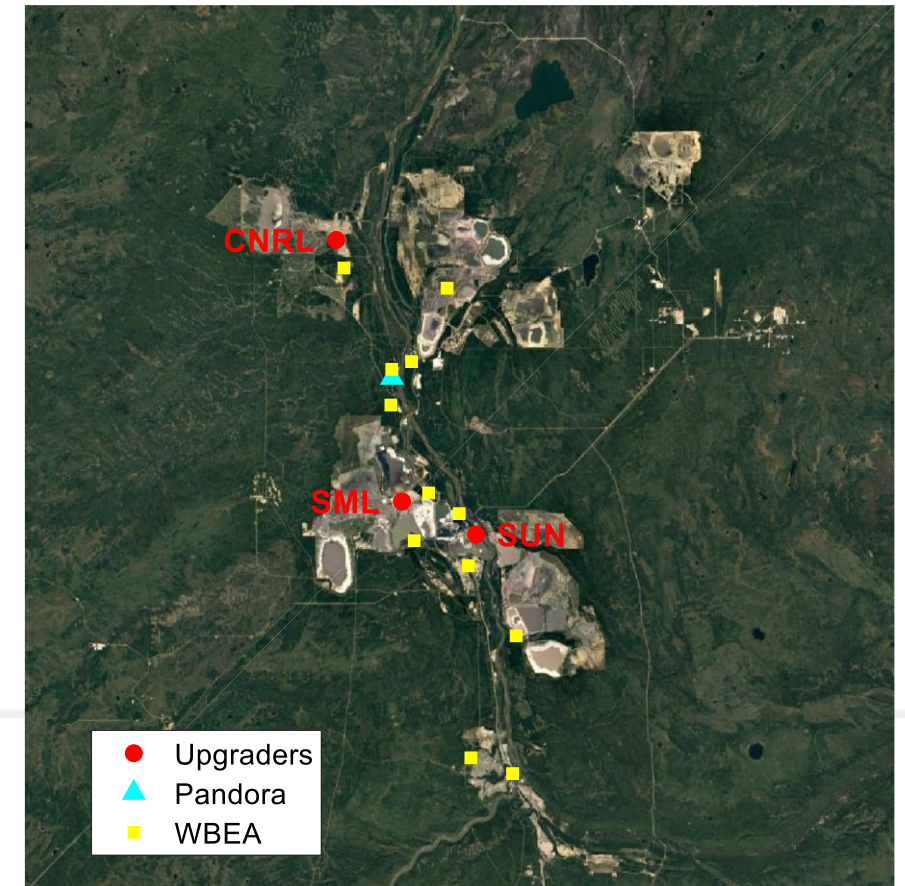
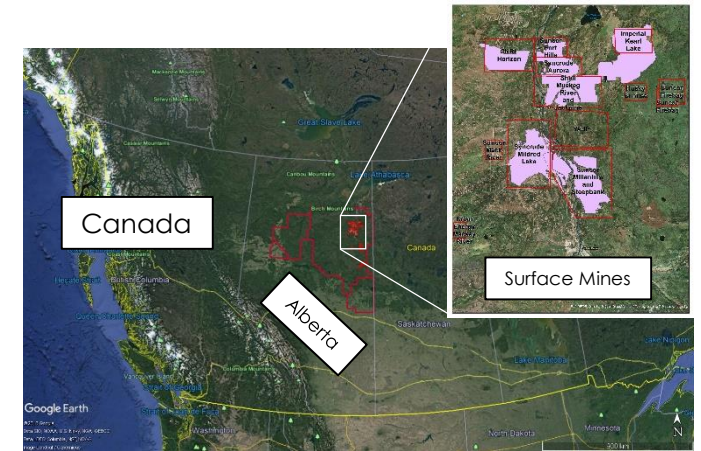
Reconciling reported ~~NO<sub>x</sub>~~  
~~and~~ SO<sub>2</sub> **oil sands** emissions  
with those derived from OMI  
and TROPOMI



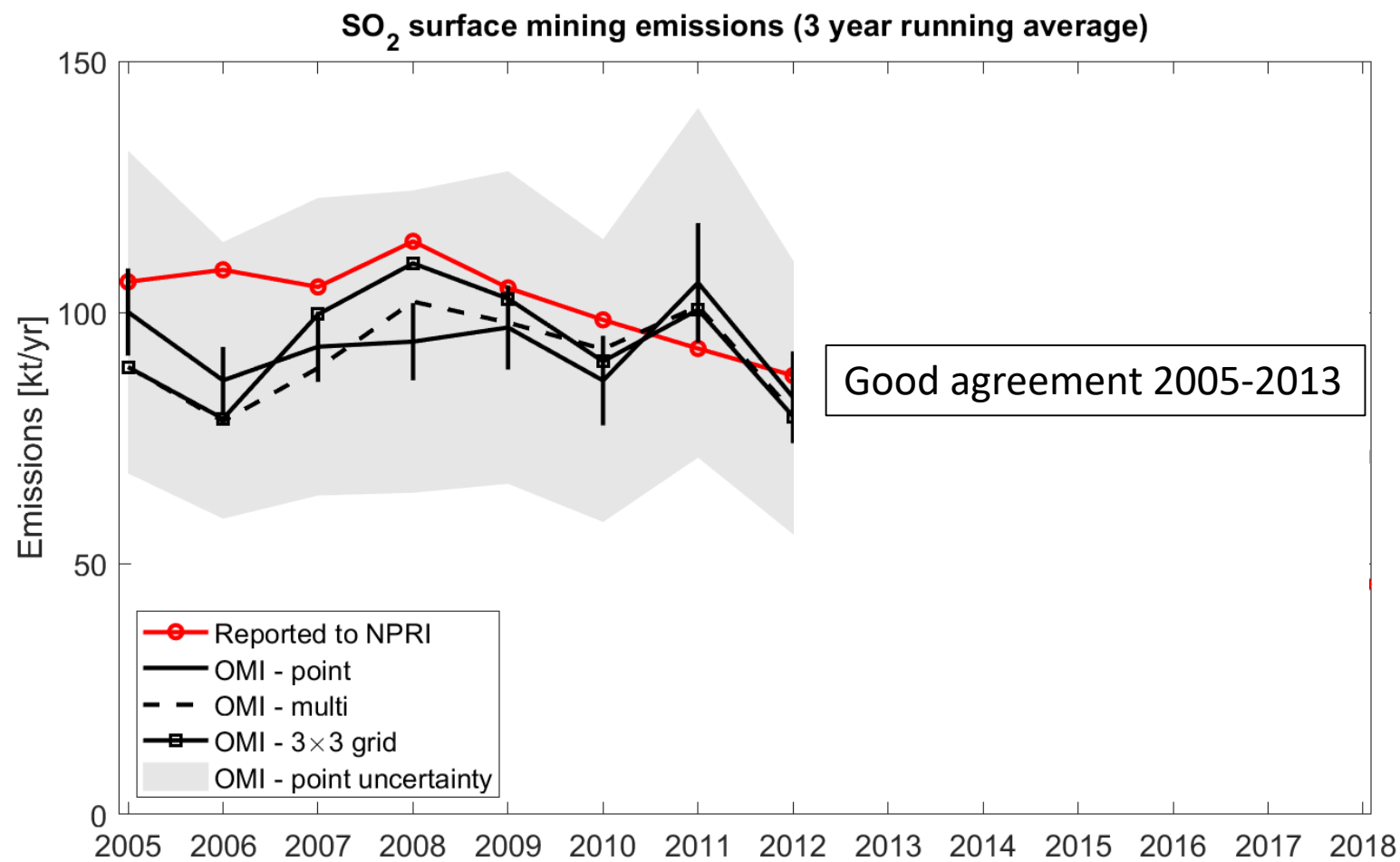
**Chris McLinden and Vitali Fioletov, Environment and Climate Change Canada**  
**Debora Griffin, Xiaoyi Zhao, Paul Makar (ECCC) and Cristen Adams (Alberta Environment and Parks)**

# SO<sub>2</sub> from the oil sands

- In the surface mining region of the oil sands, bitumen is simply dug up from open pit mines
- Roughly 100 kt[SO<sub>2</sub>]/yr is emitted, largely from two upgraders (which convert bitumen to synthetic crude)
  - Syncrude-Mildred Lake (SML) ~75%  
• Suncor (SUN) ~25%
- In 2014 additional scrubbers came on-line at SML and reported emissions fell by a factor of three



# OMI and NPRI SO<sub>2</sub> emissions



Three methods for deriving OMI emissions:

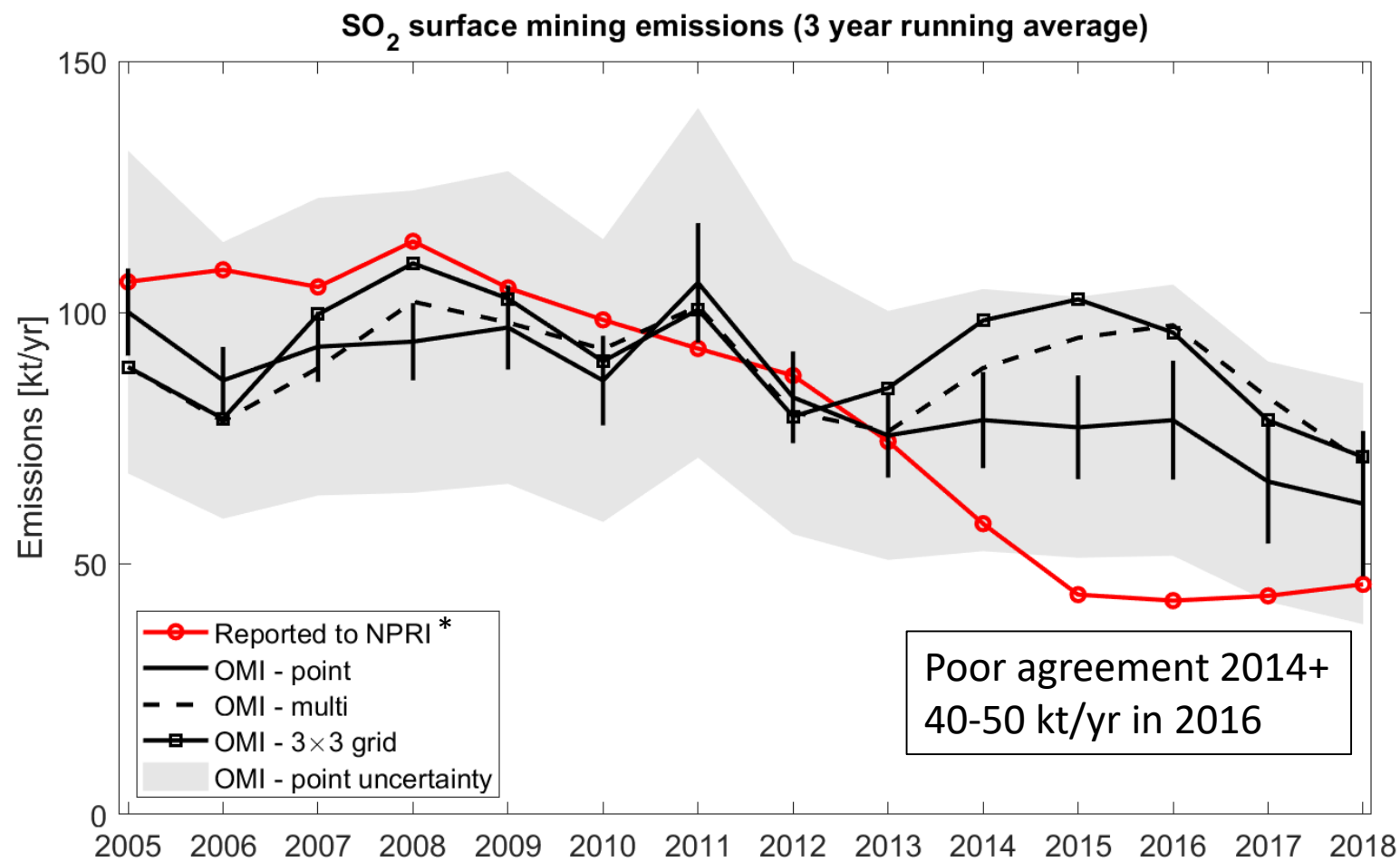
- A) Point source ([Fioletov et al., GRL, 2015](#))
  - Non-linear fit of 2D EMG to derive  $E$ ,  $\tau$ ,  $\sigma$
- B) Multi-source – prescribed locations; upgrader locations ([Fioletov et al., ACP, 2017](#))
  - Multi-linear fit of 2D EMGs to derive  $E_i$
- C) Multi-source – gridded; does not assume location of emissions ([Fioletov et al., ACP, 2017](#))
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[MEaSURES SO<sub>2</sub> emission catalogue](#)

These are based on revised AMFs that better account for spatial and temporal variability of SO<sub>2</sub> profiles and other parameters ([McLinden et al., ACP, 2014](#))

\* NPRI = [National Pollution Release Inventory](#)

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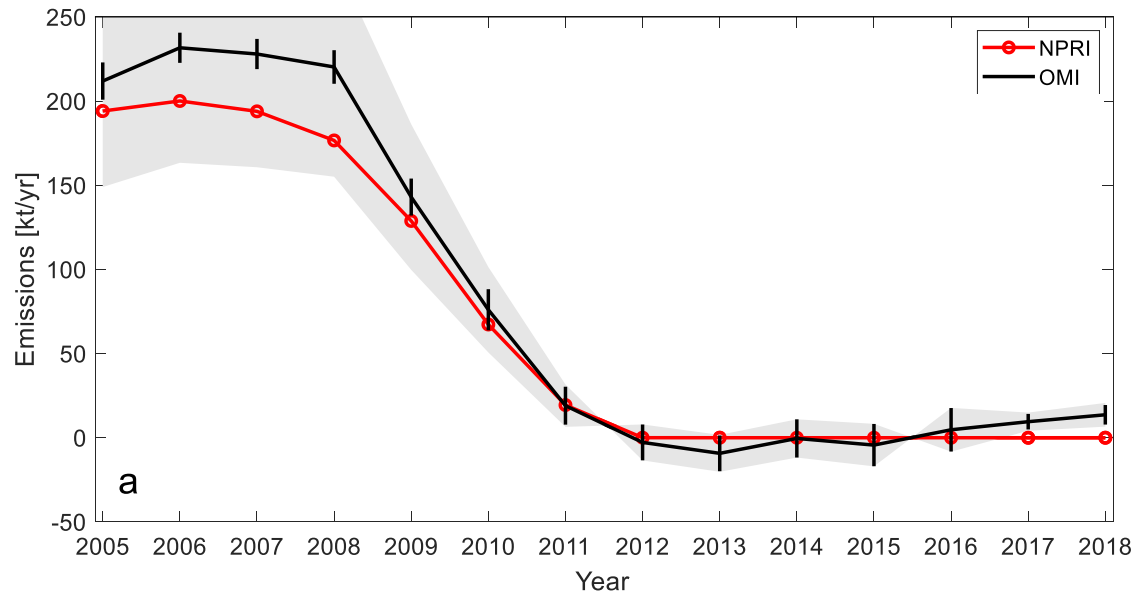
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# Other high-latitude examples

## Flin Flon smelter

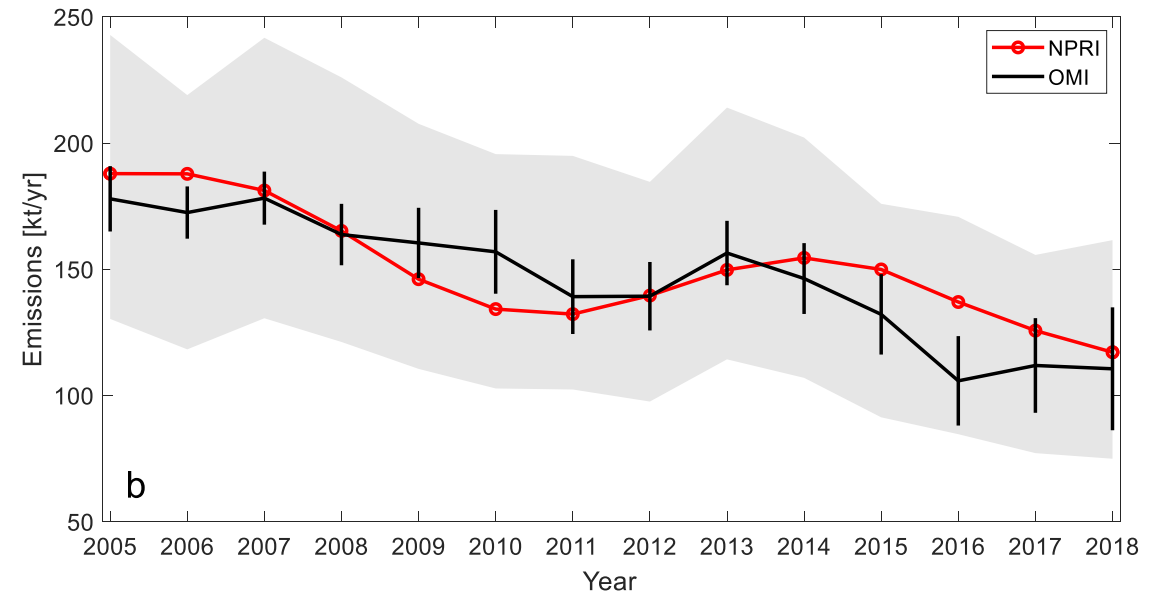
Manitoba, Canada; 54.8°N, 101.98°W

Decommissioned in 2010



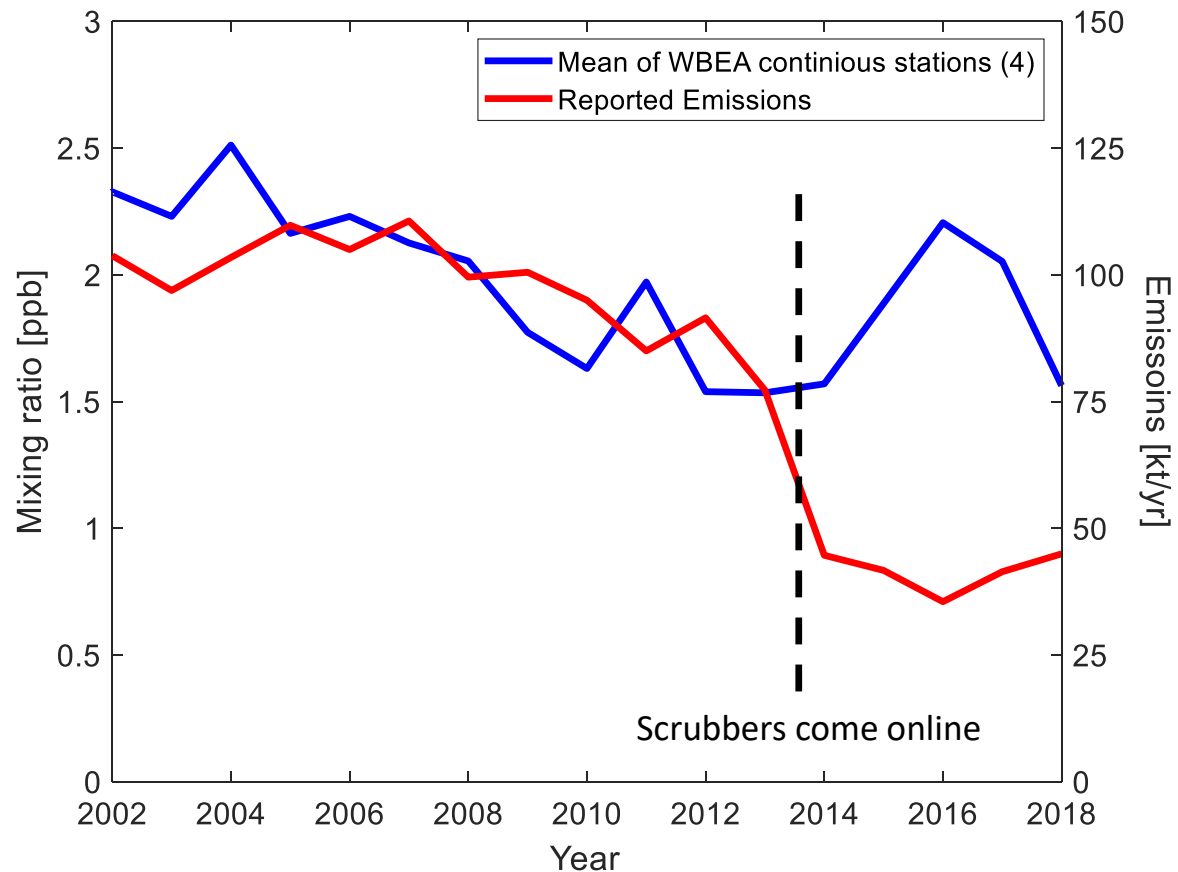
## Thompson smelter

Manitoba, Canada; 55.7°N , 97.9°W



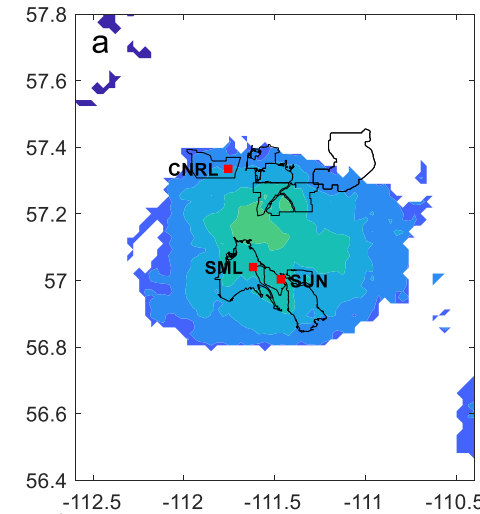
# Surface Monitoring

- Surface monitoring is largely consistent with OMI, spatially and temporally

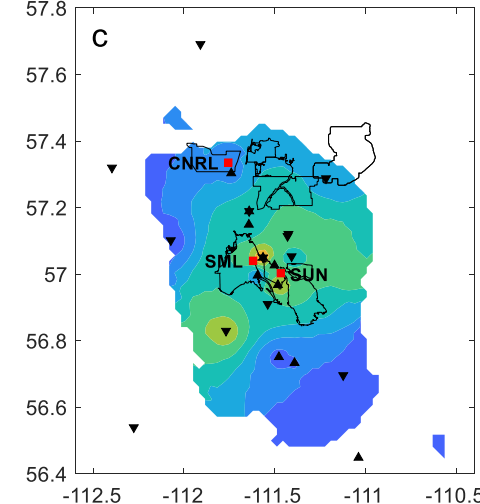


OMI

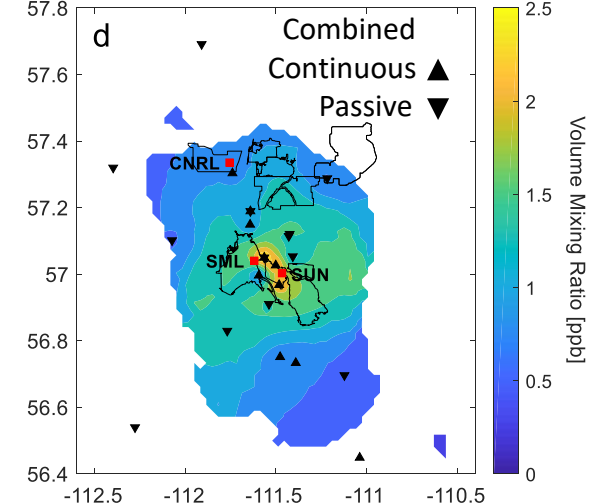
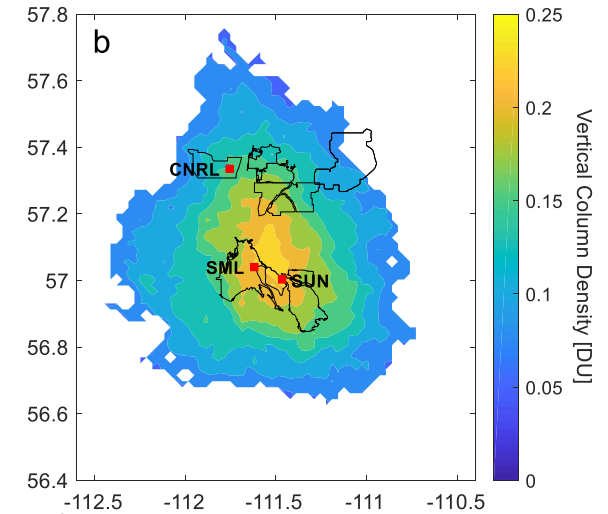
2010-2013



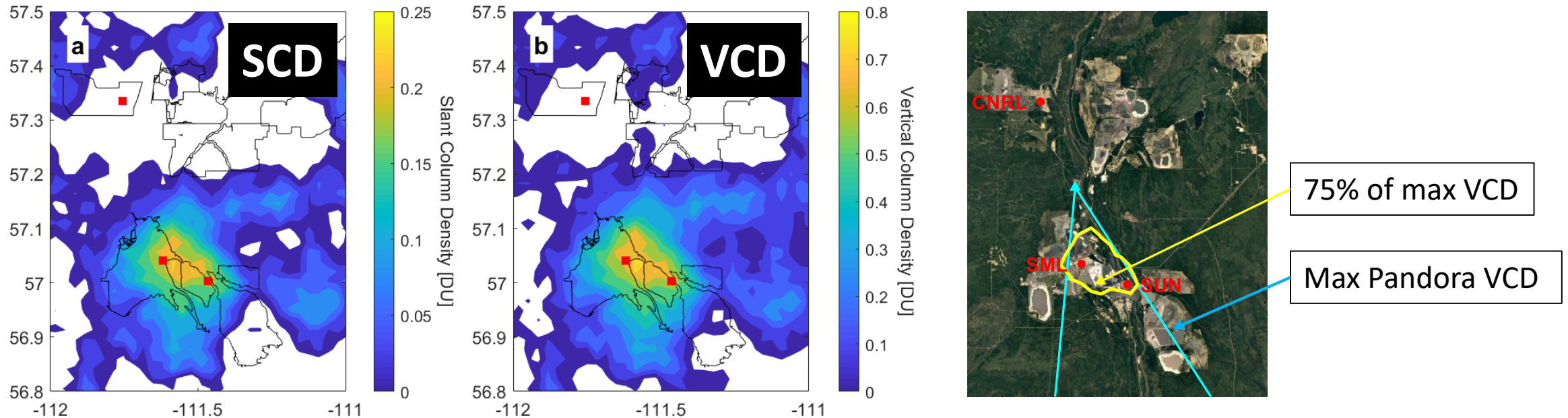
Surface monitoring



2014-2017



# TROPOMI SO<sub>2</sub>



- TROPOMI is able to more clearly delineate where emissions are coming from
- TROPOMI 2018 SO<sub>2</sub> emissions are 20% smaller than OMI 2017-2018 emissions – is this due to actual decrease in 2018 or low bias?

# Analysis

*The difference between reported emissions and atmospheric observations has yet to be reconciled*

- Assuming SO<sub>2</sub> emissions have not declined as reported, then
    - Emissions that offset gains made by scrubbers coming from new or increased source
    - This assumes scrubbers and CEMS are working as expected
  - ~90% of reported emissions from CEMS; ~10% from flaring (estimated)
    - CEMS report the expected decrease in SML emissions (75 to 35 kt/yr)
  - Could this point to increase in flaring emissions?
  - Next steps: wait for 2019 OMI & TROPOMI data + winds; talk with industry, continue working with province, more detailed analysis of surface observations
    - Since 2014 some SO<sub>2</sub> exceedances in the area are associated with 10% H<sub>2</sub>S
-

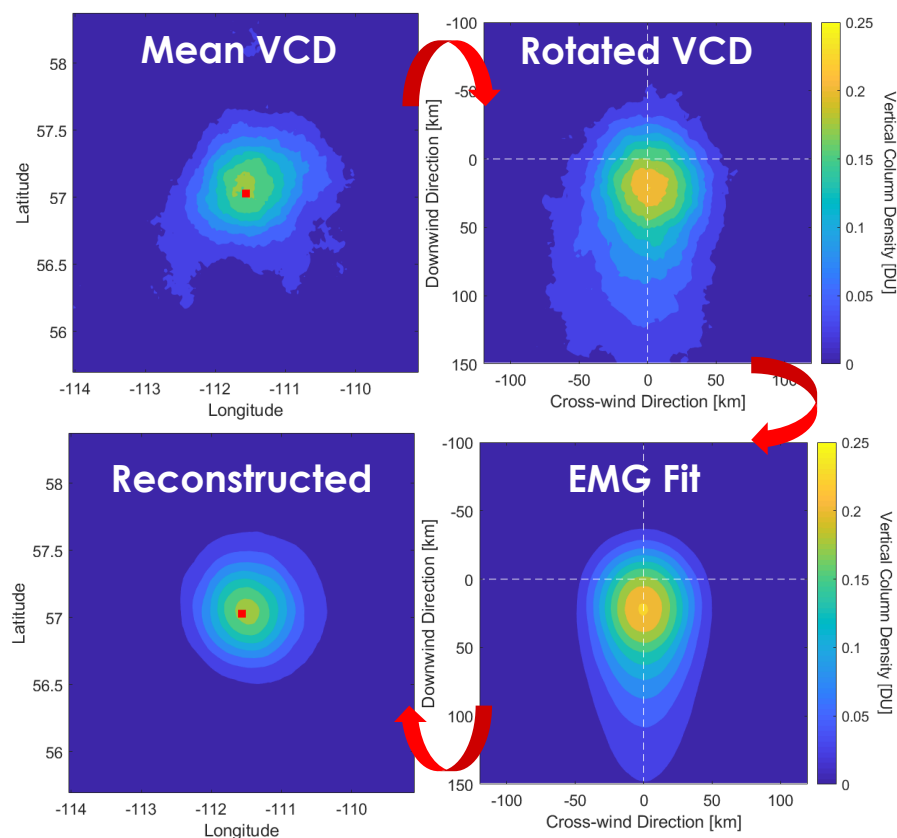
# Emissions Algorithms - Overview

Builds off of early results of [Beirle et al., Science, 2011](#)

Single, isolated point source: Non-linear fit to a 2D EMG plume model to derive  $E$ ,  $\sigma$ ,  $\tau$

[Fioletov et al., GRL, 2015](#)

OMI SO<sub>2</sub> over the Cdn oil sands



Area or multiple source approach: Multi-linear fit of many EMGs to derive multiple  $E$  while prescribing  $\sigma$ ,  $\tau$

[Fioletov et al., ACP, 2017](#)

TROPOMI SO<sub>2</sub> over the Cdn oil sands

